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SEVENTH BIENNIAL REPORT

OF THE

COMMISSIONERS

OF THE

Geological and Natural History Survey

Covering the Period from

July 1, 1908, to June 30, 1910

MADISON, WIS.
DEMOCRAT PRINTING CO., STATE PRINTER
1910

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GEOLOGICAL AND NATURAL HISTORY SURVEY.

BOARD OF COMMISSIONERS.

JAMES O. DAVIDSON,
Governor of the State.

CHARLES R. VAN HISE, *President.*
President of the University of Wisconsin.

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State Superintendent of Public Instruction.

JABE ALFORD,
President of the Commissioners of Fisheries.

SAMUEL F. PLANTZ, *Secretary.*
President of the Wisconsin Academy of Sciences, Arts, and Letters.

STAFF OF THE SURVEY, 1910.

ADMINISTRATION:

EDWARD A. BIRGE, Director and Superintendent. In immediate charge of Natural History Division.
WILLIAM O. HOTCHKISS, State Geologist. In immediate charge of Geology and of Highway Division.
F. G. SANFORD, Clerk.

GEOLOGY DIVISION:

T. C. CHAMBERLIN, Consulting Geologist, Pleistocene Geology.
WILLIAM O. HOTCHKISS. In charge, Geology.
SAMUEL WEIDMAN. In charge, Areal Geology.
FREDERIK T. THWAITES. Assistant, Geology.
R. H. WHITBECK. Assistant, Physical Geography.
FREDERICK W. HUELS, Assistant, Report on Peat.
CHARLES L. DAKE. Assistant, Geology.
HYRUM SCHNEIDER. Assistant, Geology.

WATER POWER DIVISION:

LEONARD S. SMITH. In charge.

HIGHWAY DIVISION:

WILLIAM O. HOTCHKISS. In charge.
ARTHUR R. HIRST. Highway Engineer.
MARTIN W. TORKELSON. Bridge Engineer.
HERBERT J. KUELLING. Assistant Highway Engineer.
BESS C. BREWER. Clerk.

NATURAL HISTORY DIVISION:

EDWARD A. BIRGE. In charge.
CHANCEY JUDAY. Lake Survey.
GEORGE WAGNER. Report on Fish.
F. PINKERTON. Assistant, Lake Survey.
S. D. NOURSE. Assistant, Lake Survey.

DIVISION OF SOILS:

ANDREW R. WHITSON. In charge.
F. L. MUSBACK. Field Assistant and Analyst.
LOUISE JAHNS. Analyst.
L. F. AUGSPURGER. Analyst.
W. E. BLAIR. Analyst.
E. J. GRAUL. Analyst.
A. H. MEYER. Field Assistant.
L. R. SCHOENMANN. Field Assistant.
T. J. DUNNNEWALD. Field Assistant.
O. I. BERGH. Field Assistant.
C. A. LECLAIR. Assistant.
W. E. BLAIR. Assistant.

LETTER OF TRANSMITTAL

COMMISSIONERS OF THE WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY, MADISON.

Office of the President.

July 22, 1910.

HONORABLE JAMES O. DAVIDSON,

Governor of the State.

SIR:—I have the honor to transmit herewith the report of Dr. E. A. Birge, Director and Superintendent of the Geological and Natural History Survey, for the biennial period extending from July 1, 1909, to June 30, 1910, including also a general statement of the work performed by the Survey during the summer of 1910. During this period the regular appropriation for the Survey has been $10,000, and the legislature of 1909 extended for two years a special appropriation of $10,000 annually, to be devoted to the extension of the work on water powers, Southwestern Wisconsin, and especially on highways. The amount granted and the necessities of the last department were such that no money has been expended on water powers, and the full amount of this appropriation has been devoted to highways.

The legislature of 1909 also directed the Survey to investigate and report on the soils of the state and granted $10,000 annually for two years in order to begin this work. The College of Agriculture has cooperated in this survey and the United States Department of Agriculture has given extensive aid. The extent and efficiency of the survey has been nearly doubled in this way. The immediate charge of this work has been placed in the hands of Professor A. R. Whitson and much progress has been made during the first year. The report on the soils of the Bayfield area—already begun by the Bureau of Soils—is now in the press; and the survey of Marinette county

is in the printer's hands. Dr. Weidman, with the assistance of Mr. Musback, has revised and completed the preliminary soil survey of the northwestern area and this report will be issued at an early date.

The Highway division has continued its work along lines indicated in the sixth report. Mr. Hotchkiss and the staff of engineers, Messrs. Hirst, Torkelson, and Kuelling, have greatly benefited the highways of the state directly during their four years of service. Perhaps an even more valuable service has been in educating the people and officials of the state to see the necessity and the advantage of efficiency in the expenditure of money on roads. The passage by a large majority of the constitutional amendment permitting state aid in building highways was no doubt greatly aided by the educational work of the Survey, under the State Geologist, Mr. Hotchkiss. Most of the time of Mr. Hotchkiss has been given to the highway division, both before the election and also with committees of the legislature during the session and with the special committee on highway legislation after the session adjourned. I call especial attention to the recommendations of the Director which deal with the proper manner of organizing the State Highway Department. These embody, in brief, the most important points which have come from careful study of the legislation and experience of other states. No plan should be adopted which does not secure efficiency in the expending of money appropriated by the state. Efficiency of expenditure is the central factor in successful state aid to road building. This can only be secured through a governing body wholly free in personnel and method of appointment from association with partisan politics and which has the fullest opportunity to secure the best talent in the country as road engineers.

The other departments of the Survey need less comment and may be well understood from the Director's report. Work on the lakes and on areal geology has continued about as in the past and several geological investigations have been carried out and are nearly ready for publication. I regret that no extension of the water power survey could be made during the biennial period and also that practically no work could be done in the lead and zinc district. Both these projects were authorized by the legislature of 1909, but the imperative demands of

money for the highway division exhausted the appropriation. This was understood by the committees of the legislature in fixing the amount granted to the Survey. I trust that when the legislature provides definitely for the highways of the state the Survey may use for these and similar important purposes the money now given to the highways and bridges.

Very respectfully yours,

CHARLES R. VAN HISE,
President.

REPORT OF THE DIRECTOR OF THE SURVEY.

To the Commissioners of the Geological and Natural History Survey:

GENTLEMEN:—I submit herewith my seventh biennial report as Director and Superintendent of the Survey under your charge from July 1, 1908, to June 30, 1910. I include also a statement of the work of the Survey during the summer of 1910; thus giving an account of its operations up to the time when the report goes to press.

The income of the Survey for general purposes, during the biennial period has been $10,000 annually; the same as during the period covered in the preceding report. The appropriation of $10,000 annually for two years, made by the legislature of 1907 was continued by that of 1909 (Chap. 458) for an additional period of two years. This sum has been spent almost wholly on highways, and little or no work was done on water powers or on the lead and zinc district during the biennial period. In both 1908 and 1909 the Survey received from the United States Bureau of Fisheries the sum of $500 to aid in field work on lakes; from the Wisconsin Commissioners of Fisheries $250 annually to aid in collecting Wisconsin fishes of commercial value; and personal gifts of $1,200 in aid of investigations.

A most important new duty was placed on the Survey by the legislature of 1909, which established a soil survey of the State (Chap. 403) and appropriated $10,000 annually for two years to begin the work. This investigation is carried on in cooperation with the College of Agriculture of the University and is in charge of Professor A. R. Whitson of that College. The United

States Department of Agriculture has cooperated in the survey and has placed in the field as many men as are employed by the state. Much office work is also done by the Department and its aid practically doubles the amount of work which can be accomplished during the year.

In 1908 Mr. W. O. Hotchkiss was appointed State Geologist and placed in charge of the Highway Division and of all work in geology.

I. PERSONNEL OF THE SURVEY.

The following table shows the organization of the Survey, with the names of the persons who have been employed during the past two years. The amount of money paid to each person, including compensation and allowances for field expenses, is included in the report of the Secretary of State.

Administration:

EDWARD A. BIRGE, Superintendent and Director of the Survey. In immediate charge of Natural History Division.

F. G. SANFORD, Clerk.

Geology Division:

T. C. CHAMBERLIN, Consulting Geologist, Pleistocene Geology.

WILLIAM O. HOTCHKISS, State Geologist. In charge of Geology and of Highway Division.

SAMUEL WEIDMAN, Geologist. In charge of Areal Geology in northwestern area during 1908; in Marinette Co. in charge of soil survey party in 1909.

FREDERIK T. THWAITES, Geologist. Assisted Dr. We'dman during summer of 1908 and Mr. Hotchkiss since that time.

EDWARD B. HALL, Geologist. Assistant in Areal Geology. Employed during field season of 1908 and part of 1909.

EDWARD B. SPRAKER, Geologist. Assisted Dr. Weidman during part of field season of 1909; since worked as chemist on Soil Survey.

E. H. J. LORENZ. Employed part time in making relief map of Wisconsin, 1908–10.

F. W. HUELS. Employed part time on report on Peat, 1908–10.

LAWRENCE MARTIN, Geologist. Physical Geography, summer of 1908.

G. H. COX, Geologist. Southwest Wisconsin, summer of 1908.

Highway Division:

WILLIAM O. HOTCHKISS. In charge.

ARTHUR R. HIRST, Highway Engineer.

MARTIN W. TORKELSON, Bridge Engineer.

HERBERT J. KUELLING, Assistant Highway Engineer.

BESS C. BREWER, Clerk and Stenographer since May 16.

W. C. BUETOW, Assistant Bridge Engineer. (Left Dec., 1908.)

WAYLAND C. WELLS, Clerk and Stenographer. (Died May 16, 1910.)

Natural History Division:
CHANCEY JUDAY, Biologist. In charge of Lake Survey.
GEORGE WAGNER, Biologist. In charge of Report on Fishes. Office work in sorting and arranging collections.
Field assistants, summer of 1908 and 1909.
ROY D. HALL, Chemist. Lake Survey. 1908.
CHARLES T. VORHIES, Assistant. Fish Report. 1908.
H. H. T. JACKSON, Assistant. Fish Report. 1908 and 1909.
R. T. CHRISTOPHER, Assistant. Fish Report. 1909.
GEORGE KEMMERER, Assistant. Lake Survey. 1908 and 1909.

Water Power Division:
LEONARD S. SMITH, Engineer. In charge. Small amount of work in biennial period.

Division of Soils:
ANDREW R. WHITSON, in charge.
CHARLES W. STODDART, Chemist (part time).
LOUISE JAHNS, Chemist.
F. L. MUSBACK, Assistant, Soils.
Field Assistants, Season of 1909.
T. J. DUNNEWALD.
A. H. KUHLMAN.
A. H. MEYER.
H. L. WALSTER.
R. SCHOENEMANN.
E. R. JONES.
GUY CONREY.
EMIL TRUOG.
(See also Dr. S. Weidman, Messrs. E. B. Hall and E. B Spraker, above.)

Besides the persons named above, others have been employed for special services and for short periods as stenographers, draftsmen, compassmen, and for similar temporary purposes.

II. FINANCIAL STATEMENT.

In the following table I have summarized the expenditures of the Survey according to departments, thus indicating the main directions in which the money appropriated by the State has been expended. The result is as follows:

Chaps. 375 (1901); 176 (1903):

	1908–09	1909–10
Administration	$776 18	$1,005 13
Areal Geology	4,021 31	2,834 23
Water Powers	95 00	.....
Economic Geology	2,500 60	2,220 30
Lake Biology	1,936 23	2,564 60
Report on Fish	656 67	266 75
Peat	.....	660 52
Physical Geography	.....	788 90
Lake Chemistry	247 27	.....
Total	$9,985 99	$9,340 43

Chaps. 641 (1907); 458 (1909):		
Highways	$8,853 08	$10,630 31
Physical Geography	697 36	.....
Southwest Wisconsin	501 00	.....
Peat	367 97	.....
Total	$10,419 41	$10,630 31
Chap. 403 (1909):		
Soil Survey	.....	$8,736 69

The expenses for administration include the Director's salary, $500, the pay of the clerk, and expenses for stationery, postage, printing, freight and express, etc., which are not chargeable to special investigations. In each of the years covered by this report the Director spent the entire summer—about three months—in field, office, and laboratory work associated with the natural history investigations of the Survey.

The apparent overdrafts in the Highway fund are accounted for by a balance of about $1400 to the credit of that fund from the year 1907–08. A change in the method of charging the expenses of Economic Geology was made in July, 1909. Previously all of Mr. Hotchkiss' salary was charged to that account and certain special investigations were paid out of the appropriations from Chap. 641. The greater part of that salary ($2500) should have been placed on the Highways account. In 1909–10 the salary was divided between Economic Geology and Highways, and the special investigations placed to the account of the old Survey fund.

The apparent reduction in Areal Geology in 1909–10 was due to the fact that field expenses of 1909 were paid by the Soil Survey. Most of the money credited to Areal Geology in 1909–10 ought properly to go to soils, since most of Dr. Weidman's time was given to that part of the work.

The sums as given in the statement above do not agree with the totals from the table furnished by the Secretary of State. The figures in my report refer to claims audited at this office during the period covered by the report, and always include some claims at the close of the year not included by the Secretary of State and omit at the opening of the year others included by him. The Secretary of State also includes in his report items paid from the general fund for printing and engraving.

III. WORK OF THE SURVEY.

The report of the work of the Survey for the past biennial period naturally falls into three divisions:

1. The investigations carried on under the present permanent appropriation of the Survey.

2. The new work made possible by the special appropriation granted by the legislature of 1907.

Several studies have been done at the expense of both of these funds, and the work of State Geologist Hotchkiss has been divided between investigations paid from both.

3. The Soil Survey, begun under the authority of Chap. 403, laws of 1909.

A. *Areal Geology.* In 1908, Dr. Weidman practically completed the field work for the Northwestern area of some 6,800 sq. miles (See accompanying map). In the field season of 1909 he was engaged in a soil and geological survey of Marinette county, made in cooperation with the Soil Survey of the state and with the U. S. Bureau of Soils. The soil map and report for this country is finished and was sent for publication to the U. S. Bureau of Soils. Mr. F. L. Musback of the Soil Survey assisted in 1909 in revising the soil survey of the Northwestern Area; the soil map is now completed and the report nearly ready for the press.

B. *Lakes.* The studies on the lakes have been continued by the Director and Mr. Juday. The field work has been aided, as before, by a grant from the U. S. Bureau of Fisheries. The report on the dissolved gases of the lakes has been completed and is now in the press.

C. The collecting of fishes has been continued by Mr. Wagner and the collection is now arranged and ready for study. During 1909 Mr. R. T. Christopher, of Fontana, was employed to collect the cisco of lake Geneva, so as to obtain material for a report of the food and habits of that fish.

The following investigations have been carried on under the direct supervision of the State Geologist:

D. *Peat.* A report of the peat resources of the state has been prepared by Mr. F. W. Huels and is now ready for the press.

E. A *geological map* of the state has been compiled by Mr.

Hotchkiss with the assistance of Mr. F. T. Thwaites, and is now in the hands of the engraver.

D. *A relief map* or model of the state has been made, showing the topography and the geology of the state. This has been executed by Mr. E. H. J. Lorenz with great care and attention to accuracy of detail. The map is undoubtedly one of the very best ever prepared of one of the states. Copies of this model will be furnished at cost to schools and public institutions in Wisconsin.

G. *Highway Division.* The work of this division has been carried on vigorously and efficiently under the direction of Mr. Hotchkiss. Something more than $10,000 has been expended each year, including the annual appropriation and the balance carried over from 1907–8. The staff of this division have accomplished far more than appeared possible from the limited funds at the disposal of the Survey and without doubt there have been saved to the towns and counties of the state in highways and bridges, several times the total cost of the Survey in cash, and much more in increased efficiency of expenditure of money.

H. *Division of Soils.* This work has been carried on under authority of chap. 403 of the laws of 1909 and has been one year in operation. The work has been done in cooperation with the College of Agriculture of the State University and has been in charge of Professor A. R. Whitson of that College. Professor Whitson has served without compensation from this Survey. Cooperation of the U. S. Bureau of Soils has greatly increased the amount of work done. This Bureau has placed one man in the field for each man of the Survey and has placed the charge of their work also in the hands of Prof. Whitson. During the field season of 1909 detailed study was made of about 2,175 sq. miles and reconnoissance on about 1,400 sq. miles. In addition the work already done by the Survey on the Northwestern Area has been revised and completed. This includes about 6,800 sq. miles. Much of the time of Dr. Weidman during 1909 was also given to soils as indicated under areal geology above.

I. *Miscellaneous.* Under this head may be mentioned (1) the revision of Bulletin No. VIII on the lakes of Wisconsin, by Professor N. M. Fenneman. (2) The preparation of a bulletin on the Stratigraphy and Fossils of the Middle Devonic of Wisconsin by Professor H. F. Cleland. (3) Dr. Weidman

has been revising a bulletin on the water supply of Wisconsin cities by Mr. A. R. Schultz. The two first named bulletins are in print and the third is nearly ready for the press.

DETAILED REPORT OF WORK.

A. *Areal Geology.* Under this head is also reported work done by Dr. Weidman and assistants on soils. The field work for the report on the northwestern part of Wisconsin was mainly completed during the field season of 1908. This area indicated on the accompanying map of the state (p. 17) includes nine counties, Eau Claire, Chippewa, Rusk, Barron, Dunn, Pepin, Pierce, St. Croix, and Polk, having a total area of about 6,800 square miles. During the field season of 1908, Dr. S. Weidman was assisted by Mr. E. B. Hall and Mr. F. T. Thwaites.

In making the geological survey of this area a preliminary or general reconnaissance soil survey was also made, and in this soil survey work, Mr. F. L. Musback was an assistant.

During the field season of 1909 Mr. Musback was engaged in soil survey work in this area, collecting samples of the soils for chemical analysis. During the season of 1910 some additional soil work has been done on this area in the final completion of the soil survey.

At the present time the soil map is completed, and the report describing the soils and agricultural conditions of the area very nearly finished and ready for the press. This report on the soils in the northwestern part of the state will be very similar to the Bulletin No. 11 "The Soils of North Central Wisconsin." It will be more complete, however, than the latter, on account of additional information made available by the present appropriation for the soil survey. This soil report will be of much value to the farmers of the area, as well as those outside the state who desire good farming land in this part of the state.

The report on the geology of the northwestern area is being completed as rapidly as possible, but some additional field work is required in certain parts of the area and in adjacent territory in order to finish the work in a satisfactory manner. The northwestern part of our state, adjacent to Minnesota, contains many complicated geological features of much scientific importance, and these were being investigated in co-operation, inform-

ally, with geologists of the U. S. Survey, mainly Mr. Frank Leverett, and with geologists of Minnesota, Professors C. W. Hall and F. W. Sardeson. It is desirable that at least the more important geological problems be adequately investigated and described in the geological report, for they are not only of scientific value and interest to the people of Wisconsin, to the schools, teachers, and our general readers, but also to many scientists and students outside the state.

Map showing the location of North Central Wisconsin district.

During the season of 1909, a geological and soil survey of Marinette County, in cooperation with the U. S. Bureau of Soils, was made. The soil map of the county was completed, and the soil report written and sent to the Bureau of Soils at Washington for publication in March, 1910.

The report describes the various soils of the county in con-

siderable detail and will be of much value to the farmers of the county. Especial attention to the character of soils of the undeveloped parts of the county was given, and for this reason the report and map ought to be of considerable interest to prospective settlers of the northern part of the county.

In the geological and soil survey of Marinette county, Dr. Weidman was assisted by Mr. E. B. Hall the first part of the season, and by Mr. E. B. Spraker the latter part of the season. The survey of the northern two-thirds of the county, the unsettled portion was made by a camping party, including the geological and soil assistants, compassmen, cook, and for a part of the time, a teamster.

Besides the geological assistants above named, were Geo. H. Lynes, compassman for part of the season, and James Gray and Thomas Allen, compassmen for the rest of the season. Paul Charron, cook, and H. Brightman, teamster, for part of the season. The U. S. Bureau of Soils representatives in the party were W. G. Smith and P. O. Wood in soils and J. Sazama, compassman. As already stated, the field expenses of the party were shared equally by the State Survey and the U. S. Bureau of Soils.

By means of this plan of cooperative survey the geological and soil survey of Marinette county, an area of 1,496 square miles, cost this Survey about $1.50 per square mile. While the soil survey has been completed, some additional work on the geology will be necessary in connection with the surveys of the adjacent counties of Oconto, Shawano, etc.

Report on Water Supplies. During the year 1904 Mr. A. R. Schultz, assistant geologist on the United States Geological Survey collected a large amount of data relative to wells and underground water supplies of Wisconsin. Mr. Schultz's report was later turned over to the State Survey for publication, and during the past year Dr. S. Weidman has given such time as was available to the revision of this report, getting additional data, and also including descriptions of the river and lake supplies of the cities. When completed this report should be useful to public boards of health of the state as a compilation of all available data in regard to public water supplies, sources of water supply, and the chemical composition of our various waters.

This report will probably contain about 300 pages, including

many tables of chemical analysis of water, and sketch maps showing sources of our water supplies. It is nearly completed and will now be ready for publication.

Natural History Survey, in Charge of Director Birge.

B. *Lakes.* A full report of the work of this division of the Survey was given in the Sixth Biennial Report and need not be repeated here in the same detail. The work of the Survey on lakes has been directed toward establishing some of the conditions which determine the productivity of these bodies of water. This is a very complex question and can be studied only bit by bit, especially as the Survey can afford only the time of one man to the work. The report on the dissolved gases of the lakes and their relation to the conditions of life in them is now in press. It is by far the most thorough study of the subject that has ever been made and will not only increase our knowledge on the topics immediately discussed but will also serve as a basis for other investigations in the future.

The report discusses the following topics:

I. Number, location and depth of lakes.
II. Methods of investigation.
III. The distribution of oxygen.
IV. The distribution of carbon dioxide, both free and combined.
V. The distribution of nitrogen, carbon monoxide, and methane.
VI. Mineral and sanitary analyses.
VII. Relation of chemical and biological conditions.

The nature of the report is well indicated by the following paragraph from the Sixth Report:

"The Survey has brought material for a much more complete report on the fundamental conditions of life in lakes than has ever been collected before. The course of the investigations also has made it plain that the demands of the future are rather for a careful and consecutive study of the facts in single lakes carefully selected as types, than for more numerous observations scattered widely over different lakes. The importance of the facts which have been ascertained has become increasingly plain, and as would be expected, the difficulty and the complexity of the

study have appeared also. The physical and chemical problems of lake biology are nearly as complex and difficult as are those of the soil and need to be studied by the same careful, patient, continuous and extensive methods. The report will constitute an introduction to such work. It will sketch the general facts of the physical and chemical conditions of life in lakes, but it will suggest far more problems that it will be able to solve."

The U. S. Bureau of Fisheries has continued the assistance given in former years and has aided to make the field work much more extensive than would have otherwise been possible.

The Director has published four brief papers during the biennial period, relating to the studies made on lakes.

1. An unregarded factor in lake temperatures.

2. On the evidence for temperature seiches.

Both printed in the Transactions of the Wisconsin Academy, Vol. XVI, Part II.

3. Gases dissolved in the waters of Wisconsin lakes. Read at the Fourth International Fisheries Congress, Washington, 1908; and printed in the Bulletin of the Bureau of Fisheries, Vol. XXVIII, 1910.

4. The apparent sinking of ice in lakes. Science, N. S. Vol. XXXII, p. 81.

C. *Fish.* In the summer of 1908 collecting was carried on in the western part of the state, Mr. C. T. Vorheis conducting the field work with the assistance of Mr. H. H. T. Jackson. After August 1 Mr. Vorheis withdrew and Mr. Jackson with an assistant carried on the work within the drainage area of Lake Superior and on that lake itself. Thus by the end of this season collections had been made in all parts of the state. During the summer of 1909, Mr. Jackson gave his time to those inland lakes which were supposed to contain whitefish and secured considerable collections. No field work has been undertaken in 1910, chiefly because there is no room in Science Hall to store specimens.

All specimens so far collected have been sorted and catalogued and are ready for detailed study. Much of the time during the past two winters has been devoted to gaining a knowledge of the whitefishes; this work is now almost completed and an account of the *Salmonidae* of the state will probably be written next winter. In the course of the work it ap-

peared that some specimens of cisco from the deep waters of Lake Michigan were different from any known species and Mr. Wagner described them as *Argyrosomus johannae* in Science, N. S. Vol. 31, p. 957. He also found that the stickleback of Lake Superior, described as a new species by Agassiz, and long supposed to be different from the form in the other waters of the state, is not entitled to a separate name. (Science, N. S. Vol. 32, p. 28.)

During 1909, an effort was made to ascertain the depth-migrations, if any, of the cisco of Lake Geneva. Mr. R. T. Christopher of Fontana was employed to collect the fish throughout the open season. A good many myths have arisen concerning the form in Lake Geneva, due chiefly to its sudden and spectacular appearance at the surface in June, at the time of the emergence of the certain species of May-flies on which it feeds. Our work seems to show clearly the following: The cisco during the period that the lake is free from ice, shuns the shallow water along the shore. Outside of this, they seem to occur at all depths at all times, even to the deepest parts of the lake. From these last, however, they are excluded by the absence of oxygen in the bottom water after the middle of summer. The nature of the catches indicates that they travel in large schools rather than singly. They favor certain areas of the lake, for reasons at present unknown. During the season of our observations their food consisted almost wholly of copepods. In winter, however, the fishermen use minnows exclusively as bait. Spawning evidently takes place in November, though weather conditions prevented us from carrying our observations through this period.

Geological Work in Immediate Charge of W. O. Hotchkiss.

D. *Peat.* A report on Peat, by Mr. F. W. Huels, has been prepared under the direction of Mr. Hotchkiss and is practically ready to be sent to press. The following outline shows the manner in which the subject has been treated:

Introduction.

Part I. Origin, Occurrence and Characteristics of Peat.

Chap. I. Peat, its origin, occurrence and characteristics.

Part II. The Peat Deposits of Wisconsin.
Chap. II. The formation of peat in Wisconsin.
Chap. III. Prospecting and testing peat deposits.
Chap. IV. The peat deposits of Wisconsin prospected in 1903.
Chap. V. The peat deposits of Wisconsin prospected in 1908.
Chap. VI. Summary of the characteristics of Wisconsin peat.
Part III. Attempts to develop Wisconsin Peat Deposits.
Chap. VII. The manufacture of produce gas from Wisconsin peat.
Chap. VIII. The products of distillation of Wisconsin peat.
Chap. IX. Wisconsin peat and its by-products.
Chap. X. The manufacture of Wisconsin peat into fuel.
Chap. XI. Miscellaneous attempts to utilize Wisconsin peat.
Part IV. Possibilities of the Development of a Peat Industry in Wisconsin.
Chap. XII. Peat as a fuel.
Chap. XIII. Gas from peat.
Chap. XIV. Peat as a raw material other than fuel.
Chap. XV. Some factors influencing the successful utilization of a peat deposit.
Chap. XVI. Conclusions.
Appendix A. T. C. Chamberlin on Wisconsin peat deposits.
Appendix B. Bibliography.

E. *New geological map of the state.* Owing to the fact that for a considerable time there has been no geological map of the state available for distribution, Mr. Hotchkiss, assisted by Mr. F. T. Thwaites, has collected and put together geological data from surveys that have been made since the last geological map of the state was published. This information has been embodied in a geological map of the state which is now in the hands of the engraver and will be ready for distribution probably some time during the winter of 1910–11.

In making this map the present base of the state railroad map was enlarged and corrected from information obtained from many sources. In making these corrections, the maps and rec-

ords of the present survey were used; also topographic sheets of the United States Geological Survey; unpublished maps by Samuel Weidman and Dr. Birge of this Survey, and by Wm. C. Alden of the United States Geological Survey; various county maps, detailed railway surveys, etc. The geological formations as shown on the old geological map of the state were corrected from published reports of this survey and the United States Geological Survey, also from unpublished works by Samuel Weidman of this survey, and by Wm. C. Alden of the United States Geological Survey.

Information was obtained in connection with the work of the highway division which permitted of the construction of a complete road map of the state. The roads are shown in a special color on the geological map. Arrangements have been made with the State Automobile Association to indicate the main traveled automobile roads on the proof of this map, so that the map will be of great value to tourists. The map will be published on a scale of six miles to the inch, which will make a wall map about 52 by 54 inches.

F. *Model of Wisconsin.* A relief map of the state was completed early in 1910. This model was made under the direction of Mr. Hotchkiss, from information collected by him and Mr. Thwaites. The modeling was done by Mr. E. H. J. Lorenz, an expert model maker who was employed by the survey for this purpose. The model gives an excellent idea of the topography of the state. It was constructed in a careful manner so as to show the hills and valleys as accurately as could possibly be done on the scale adopted, the horizontal scale being seven miles to the inch and the vertical about 2,500 feet to the inch. This model was made for use in the various educational institutions of the state and in state departments for exhibition and similar purposes, and copies are supplied for these public uses at the cost of manufacture. The entire cost of the original model has been borne by the Survey.

The cut of the model which is given herewith, together with the following description which is taken from the title on the model, gives a good idea of the topography of the state.

THE SURFACE OF THE CRYSTALLINE ROCKS.

"Wisconsin possesses a great variety of topographic forms. The oldest is a great area of crystalline rocks worn down by long ages of weathering and stream action from an original condition that must have been more or less mountainous to a gently rolling surface above which the remnants of the hardest rocks project as hills. This type formerly existed over the whole surface of the state but now is best shown in Marathon County.

"On this old flat surface the sea deposited the sandstones, shales and limestones, the existing parts of which now cover, in crescent shaped belts, the southern half and the eastern and western edges of the state, and a small area around Ashland and Superior.

THE SURFACE OF THE LATER ROCKS.

"When these later rock formations were raised above the sea the streams and weather began to wear them down. The weaker rocks were worn away rapidly and the stronger rocks more slowly. As a result there are prominent limestone ridges, as Military Ridge, extending from Madison west to the Mississippi River, and the Niagara Escarpment making the eastern edges of Green Bay and Lake Winnebago and extending south to Waukesha County. As a result of this differential resistance to erosion there are narrow valleys in the limestone and wide valleys in the sandstone and shale. The Wisconsin river illustrates this. Its mouth is in resistant limestone and the valley is narrow. South of Richland and Sauk Counties the valley is in weak sandstone and is much wider.

"The resistant limestones stand as continuous ridges, as in Grant and Crawford Counties, but where the sandstone forms the divides it has been eroded to a much greater extent, as in Buffalo, Trempealeau and Monroe Counties, leaving more or less isolated peaks where the ridges once were. This process was carried further in Jackson and Juneau Counties where the sandstone was worn to a great sandy plain with only a few harder parts of the sandstone projecting as mounds above the general level. The soft Cincinnati shale was also cut away

to form the interior lowland in which Green Bay and Lake Winnebago lie.

The Glacial Features.

"After the surface of the state was developed to about this stage great ice sheets from the north covered all but the southwest quarter of the state. This Driftless Area shows the kind of topography that existed in the other parts of the state before the glaciers came. These glaciers moved across the country, wearing down the hills somewhat and filling up valleys, sometimes to a depth of 500 feet with the boulders, gravel, sand and clay which they carried. The old drainage systems were thus obliterated, and thousands of lakes and swamps were formed in this uneven glacial drift. Numerous waterfalls and rapids also resulted, giving many sites for the development of water power.

"The large amount of silt, sand and gravel carried by the streams from the melting ice filled the stream valleys. As a result of this filling the Mississippi bottom lands are over 150 feet above the rock floor of the valley. On the eastern edge of the state the glacial lakes left large flat areas of clay deposits which make rich level farm lands and valuable brick clays.

"The borders of the ice sheets (shown on the model by a dashed line are in many cases marked by knob and kettle ridges called moraines. There are long, low hills, called drumlins, in Dane, Dodge, Columbia, Jefferson and Fond du Lac counties. Their longer dimensions correspond with the direction of movement of the glacier which formed them.

Influence of the Topography.

"The influence of the topography upon the history and economic development of the state is worthy of attention. The old water routes like the Fox-Wisconsin, are to be seen, also the features influencing the location of cities, railroads, and the industries dependent on water power. The influence of the topography and soil on agricultural conditions as well as on the relative development of different parts of the state is easily seen."

Report on General Geology of the State. In the last biennial report it was mentioned that plans had been made for a bulletin giving a general statement of the present knowledge of

the geology of Wisconsin. This bulletin will be written in non-technical language so that it might be useful to high school students and to the ordinary reader. Owing to the pressure of other work it has been impossible to get this work done, but it is hoped that it will be possible to send it to the press some time during the year.

HIGHWAYS.

G. *Highway Division.* From the end of the period covered by the last biennial report until June 30, 1909, the work of the highway division was continued under Chapter 641 of the laws of 1907. The legislature of 1909 passed a new law (Chapter 458) continuing the work of this division for a second biennial period.

At the general election of 1908, Section 10, Article 8 of the state constitution was amended so as to permit the state hereafter to give aid to towns and counties in building highways. This amendment was passed by a majority of nearly three to one and exceptionally large vote was registered. This result was largely due to the great amount of educational work accomplished by the highway division and the State Good Roads Association organized by Mr. Hotchkiss.

After the passage of this amendment, at the request of some of the members of the legislature, Mr. Hotchkiss undertook a very thorough study of the laws providing for state aid in other states and drafted a bill providing for state aid in Wisconsin. This bill was submitted to various members of the legislature and to other state highway departments for criticisms and suggestions, and after being revised in accordance with these was introduced by the Senate committee on roads and bridges. Owing to various circumstances, the legislature decided not to take any action with regard to state aid for roads, and appointed a special committee to consider the matter and make a report which would be acted upon at a special session which it was proposed to hold.

This committee met in September, 1909, and organized. They decided that the best means of finding out the needs of the state would be to hold public hearings in various sections of the state. At the invitation of the committee Mr. Hotchkiss accompanied

them on their trip and attended the hearings. After these hearings were completed, the committee delegated two of their members to draw up a bill and prepare a report. When this work was done, the committee were divided as to its merits, the majority signing it, however. It is the opinion of the highway division that this bill drawn up by the committee is exceedingly complex a ndill advised in many ways. A shorter and much simpler bill can be drawn to cover the same ground. In the latter part of the report recommendations as to highway legislation are given.

Since the last biennial report, the work of the highway division has been carried on under the direction of Mr. W. O. Hotchkiss as chief, with Mr. A. R. Hirst as highway engineer, Mr. M. W. Torkelson as bridge engineer and Mr. H. J. Kuelling as assistant engineer. The work accomplished is most easily described under the three headings used in my last biennial report:

1. Road Work.
2. Bridge Work.
3. Educational Work.

Road Work.

Owing to the rapidly increasing interest in the building of better roads throughout the state, the assistance of the highway division has been demanded by many more localities than could be served. It was not possible within the limits of the appropriation to provide men enough to give the assistance which the local people needed and asked from the State. The work of this division has extended in one form or another into every county of the state except Vilas. As the work is all done upon the request of the local people, it is quite apparent that the demand for this assistance has been quite uniformly distributed over the whole state. The roads constructed under the direction of the highway division have called for the expenditure of about $136,000 on the part of towns and counties.

The road work has consisted of inspecting roads which towns desired to improve and give general advice upon the work which the towns afterward were to carry out. Over 114 roads in 32 counties have been thus inspected. In many cases it has been necessary to make surveys and plan the road and make detailed

estimates of its cost. Such plans have been made for cutting down hills and filling hollows and bringing the grade of the road more nearly to what it should be. Ninety such road surveys in 22 counties have been completed, and many more applications are waiting their turn.

The arrangement mentioned in the last biennial report according to which the highway division has had the use of steam rollers and stone crushers has been continued. This machinery has been of great value to the state. It has enabled the people to see the value of modern road machinery as the means of road construction and many counties have purchased machinery of their own. This state road machinery has been used in 13 counties in the construction of 24 different roads. The list of the counties where it has been used includes Ashland, Columbia, Grant, Jefferson, Kenosha, La Crosse, Milwaukee, Monroe, Portage, Rock, Rusk, Sauk and Waukesha. There were a great many more applications for the use of this machinery than it was possible to grant, in spite of the fact that the machinery is loaned under what might be considered unfavorable circumstances. The funds at the disposal of the highway division made it necessary for the town using the machinery to pay for the freight and all the expenses of operation.

In connection with the road work a great amount of data has been collected from town clerks and other local officials with regard to the local roads. These data have been embodied in a new geological and road map of the state now in the hands of the engraver. This map is described on page 15.

BRIDGE WORK.

One of the most widely appreciated branches of work in the highway division has been the assistance which it has offered to towns and counties in their bridge work. Before the highway division took up this work, the county and town bridge committees had no engineering assistance whatever in letting their contracts. When they notified bridge companies that there would be a letting on a certain day, every bridge agent who appeared had different plans to present and different prices. As a result of this system it was impossible for the officials to determine which was the best bridge for the money and the one most suited to their needs. When the assistance of the highway divi-

sion is requested, an engineer is sent to visit the bridge site, make proper inspections and obtain all data necessary for making plans and a very careful estimate of the cost of the bridge. The data for letting the contract is agreed upon and the highway division thereupon notifies all bridge companies doing business in the state as to the kind and location of the bridge to be let, and if they desire to bid, furnishes them with copy of plans of the bridge and specifications under which it is to be erected. In this way all bids are on the same structure, one which is designed properly to fit local needs, so that in letting the contract the only thing that need be considered is the price. This assistance has been very highly appreciated by a large number of town chairmen. There have been 277 bridge inspections made upon requests which have come from all but seven counties in the state. The total cost of the bridges, the contracts for which we have assisted in letting, has been approximately $175,000. Many other bridges have been designed and plans sent directly to the town boards who have let their contracts; and a great many plans for concrete culverts have also been distributed, but there is no record of the number of times which these plans have been used. One town alone has built nearly 40 culverts and small bridges of concrete on the plans of this division.

The improvement which the bridge work of the highway division has been able to effect in the quality of highway bridges throughout the state is very noticeable. The usual remark made by the county committee or the town chairman when they have completed a bridge planned by this division is that they "have the best bridge in the county at the lowest price." Sometime ago a statement of the amount saved to their several towns was compiled from estimates given in letters from various town chairmen writing on this matter. These letters tell that on the 16 bridges to which they relate the total saving was estimated by the town chairmen at $7,500. The saving on the whole 277 bridges cannot be estimated. The appreciation of the town chairmen of this saving is perhaps best illustrated by the two following extracts from letters received by the division.

Barron, Wis., Jan. 16, 1909.

"I regard the Bridge Department of the State Highway Division almost of an inestimable value to town and county officials

in aiding them to buy better bridges at less cost and the satisfaction of knowing that they will not be skinned. The bridge letting of the new Hewitt bridge is perhaps the first letting in Barron county where a contract was entered into binding on both parties. Heretofore the usual practice has been to bind the town and county board only.

"The plans furnished us by your department saved the town of Chetek $575 on abutments on the Whitman bridge last year.

"When we were contemplating building the new Hewitt bridge I asked for estimates of cost from the various bridge companies and the cost varied from $6,800 to $7,500. We appropriated $5,400. Under the direction of the state highway division we proceeded to do some of the work ourselves by building the pier and abutments at a cost of about $1,100 as against $3,200 asked by bridge companies. On the whole job it is safe to say that the towns of Chetek and Dover have been saved $1,500 by asking the aid of the Highway Division, and especially the untiring efforts of Mr. Torkelson, the Bridge Engineer."

(Signed) J. A. H. Johnson.

Graytown, Wis., Dec. 12, 1908.

"We are satisfied that on the Allen Bridge which was built entirely on your plans and the contract let by your directions the town saved four or five hundred dollars at least. We also used your plans in building the abutments to the bridge we built on the county line between this town and the town of Vance Creek. It made a very neat and substantial job. With your help we have been able to do business with the bridge companies in an intelligent manner. Heretofore we have been obliged to take their word for about everything, including design, construction and price."

(Signed) C. B. Thatcher.

EDUCATIONAL WORK.

As stated in the last biennial report, it has been recognized by the highway division that the most important part of the work in the beginning was to arouse people to an interest in road building. There are nearly three million dollars a year being spent on roads and bridges in the state at the present time. If this money could be properly spent there would be

no need for any outside assistance to secure good roads. The difficulty comes from the fact that the money is all spent under the direction of men who have had little or no experience in the economical building and maintaining of roads and bridges, and so about fifty per cent of it is wasted.

Many newspaper articles on good roads have been sent out and the press of the state has assisted by showing great interest in this matter. Good road talks have been given at farmers' institutes, business men's clubs, various state conventions, etc. In all, 257 such talks have been given in 63 counties. The supply of the four road pamphlets described in the last biennial report became exhausted and it was necessary to get out a new edition. These pamphlets have been exceedingly popular because of the simple, practical directions for road and culvert building which they contain.

The correspondence course in road building given in connection with the Extension Department of the University has been continued.

The result of all this educational work has been a greatly increased interest in road building and a marked improvement in local methods, the value of which cannot be estimated in dollars and cents, but which is very evident to one who has given attention to the condition of the roads in the last few years.

SOIL SURVEY, IN CHARGE OF PROFESSOR WHITSON.

H. *Division of soils.* The soils constitute by far the greatest single natural resource of the state, since they are the source of all agricultural products. A knowledge of their nature and of the distribution of the different varieties lies at the basis of their intelligent use. At present we have only a very imperfect and general knowledge of the soils. A very general map of the soils of the state was prepared by Professor Chamberlin in connection with the first complete geological survey of the state. In connection with the survey of the areal geology, the present Geological and Natural History Survey has prepared a preliminary survey of the soils of a portion of the newer part of the state, approximately 14,000 square miles in area.

Realizing the necessity of a much more complete survey of the soils of the state than the appropriation for this survey has heretofore made possible, the legislature of 1909 made an ap-

propriation to the Survey of $10,000 annually for two years to start the work of such a survey, which, it is expected, will require a period of approximately ten years to complete. The statute establishing the survey directed that the work be done in cooperation with the College of Agriculture of the State University. This cooperation has been effected; Dean Russell is consulted regarding all parts of the work; the college provides quarters for the laboratory work of the survey; and the immediate direction of the work is in charge of Professor A. R. Whitson of the College of Agriculture.

Cooperation from the Bureau of Soils of the United States Department of Agriculture has also been secured, by which the extent and efficiency of the work of the Survey is greatly extended. The Bureau of Soils places in the field the same number of men as this Survey and bears half the expenses of field parties. Arrangements for publication of results have also been made with the Bureau of Soils. Professor Whitson is placed in charge of all the work on soils, whether done by the State or the Department of Agriculture.

The plans proposed at the time of the making of this appropriation, included a detailed survey of the older portions of the state and a preliminary survey of the remainder of the newer portions not already surveyed in connection with the areal geology.

The work of the detailed survey was begun July 10, 1909, in Iowa, Waukesha and Waushara counties and an area bordering on Chequamegon Bay and the Apostle Islands. Work had been undertaken on the last mentioned area by the Bureau of Soils prior to arrangements of cooperation at the request of persons interested in fruit raising in that section. During the summer of 1909, the field work on the Bayfield and Waukesha areas was completed and in the spring of 1910, work was begun in Juneau and Fond du Lac counties and that in Waukesha and Iowa continued. During the first year, a detailed survey has been made of approximately 2,175 square miles. In this detailed work, the soils are mapped on a scale of one inch to the mile and areas as small as ten acres in extent are shown. The soils are classified into types and series as determined by agricultural conditions, such as texture, topography, drainage and by mode of origin.

This field work has been done by Messrs. T. J. Dunnewald, Arthur Kuhlman, A. H. Meyer, L. R. Schoenmann and O. E. Baker.

Chemical analyses are being made of representative samples of all types mapped. These analyses will show: total nitrogen, phosphorus and potassium; phosphorus soluble in N/5 nitric acid, carbon dioxide in carbonates, total organic matter and degree of acidity. The chemical laboratory of the soils survey has been under the charge of Prof. C. W. Stoddart, who has devoted approximately one-third of his time to this work. He has been assisted by Miss Louise Jahns, Mr. Guy Conrey, Mr. F. L. Musback and Mr. E. B. Spraker.

The reconnaisance work was begun in Marinette county about the middle of July, 1909, and that area, of approximately 1,400 square miles, was completed during the fall. The field work in this area was under the immediate charge of Dr. S. Weidmann in connection with the survey of the areal geology of that county.

Owing to the unsettled condition of the newer portion of the state, it was found necessary to organize a camping party in order to make the preliminary survey of this county as planned. It has proved more expensive to conduct the preliminary survey under such conditions, where the lines of traverse follow section lines, than to make the detailed survey in the more settled portions of the state. It was deemed best, therefore, to abandon this plan for the preliminary survey in future, and to survey the remainder of the northern part of the state in less detail, using such roads as are accessible without camping parties. During the season of 1909, the preliminary survey of the soils of the area previously begun in the northwest central part of the state was revised by Dr. Weidmann with the assistance of Mr. F. L. Musback.

Reports on all of these areas are now in progress of preparation and will contain a general statement of the climate and agriculture of these areas; full description of the types of soils as mapped; the chemical analyses; and tentative suggestions in regard to special treatments which the soils require in order to yield the best results to the farmer. These reports will be prepared by the state organization in cooperation with the Bureau of Soils of the United States Department of Agriculture.

It is expected that a final report on the soils of the state, including a more complete discussion of their agricultural use will be made at the close of the work of the survey of the entire state.

The great value of this survey of the soils of the state is already manifest. A number of areas have been found which require special treatment to enable them to produce the largest crops which they are capable of yielding.

I. *Work of the present season.* 1. *Geology Division.* The work under immediate direction of Mr. Hotchkiss will consist in writing the general report on geology and of three new lines of work. Arrangements have been made with Professor Whitbeck of the State University to take up the study of the geography and industries of the state and write a report which will be issued as one of the educational series of bulletins. This report will be a valuable text and reference book for use in the schools of the state.

Another line of work for the present season is a study of the Lake Superior Sandstone. This will be a scientific study taken up for the purpose of correlating this sandstone with the sandstones of the central part of the state.

Mr. Hotchkiss personally will lead a party in Florence County making a study of the iron district in the northeastern part of the state. No work in this district has been done by any geological survey since that done under Major Brooks of the former state survey in 1875. A great amount of development has taken place since that time and mining men are taking an active interest in the district at the present time. Owing to the importance of this work, it has been possible to arrange with the United States Geological Survey to have them undertake the making of topographic maps of the district so that the geology may be published on a topographic base map. The United States Geological Survey will probably expend more than $10,000 in making these maps.

Dr. Weidman will give his time to completing his report on the Northwestern Area; the first part will consist of the report on soils, which will soon be finished.

2. *Natural History Division.* The report on lake gases and biology is in the press and the first work is to attend to issuing this bulletin. Not very much field work will be done this sum-

mer. A party at Waupaca is carrying on observations on the lakes of that place, in order to finish certain details for the report. Some field work preliminary to new studies will be done. The Director and Mr. Juday expect to spend some time on the lakes of central New York, under the auspices of the U. S. Bureau of Fisheries, extending to the deeper lakes of that region the studies made on Wisconsin lakes.

No work will be done to extend the collection of fishes as the Survey has now no room in which to store any additional material.

3. *Highway Division.* The work of this division is proceeding along the lines established in the past and indicated in this report. All of the funds granted by Chap. 458 of the laws of 1909 will be needed for highways and nothing can be spent on water powers of the lead and zinc region.

4. *Division of Soils.* The field work of this division is progressing rapidly. La Crosse county will be taken up after the completion of Iowa county. The detailed surveys of Juneau, Waukesha and Fond du Lac counties will be completed, and reconnoissance surveys are being made in Bayfield county and in the region of the Forest Reserve. In the last, work is done in cooperation with the State Board of Forestry.

The exact areas which will be covered by the different parties can not be accurately stated at present, but they will be considerably larger than last year.

Reports on areas surveyed last year will be completed and turned over to the U. S. Bureau of Soils for publication.

IV. PUBLICATIONS.

The Survey has issued less during the biennial period than in any previous one. The only publication has been the supplementary atlas of maps of additional areas in the lead and zinc district. These cover 89 square miles and were fully described in the Sixth Report. Besides these there have been reprinted Bulletin No. XI on the soils of northwestern Wisconsin by Dr. Weidman and the four Road Pamphlets by Mr. Hirst.

There are now in the press and about ready to issue (1) a new and revised edition of Bulletin No. VIII. The Lakes of Southeastern Wisconsin, by N. M. Fenneman. (2) Bulletin No. XXI.

Scientific Series No. 6. The fossils and Stratigraphy of the Middle Devonic of Wisconsin, by Herdman F. Cleland. There is in the press Bulletin No. XXII, Scientific Series No. 7. The The Inland Lakes of Wisconsin; the Chemistry and Biological Relations of the Dissolved Gases, by E. A. Birge and Chancey Juday.

In the hands of the engravers are the following maps: (1) The maps for the soil report and geology of Northwestern Wisconsin. (2) The general geological map of the state.

The U. S. Bureau of Soils is issuing the map and report of joint work on the area in Bayfield county. The Survey has transmitted to this Bureau, for similar issue, the report on the soils of Marinette county.

The following reports are nearly ready for the printer: (1) A report on the underground and other waters used as a source of domestic supply in Wisconsin, by A. R. Schulz, revised by S. Weidman. (2) A report on the Peat Resources of the state, by F. W. Huels.

V. FUTURE WORK OF THE SURVEY.

During the past two years the Survey has begun one most important piece of new work. This is the Soil Survey whose establishment was authorized by the legislature of 1909 and $10,000 annually for two years was appropriated to begin the investigation. This will doubtless be continued and this most necessary survey pushed on to completion. In other lines the Survey has done little except carry on work already begun. As has always been the case, most of the money has been spent on geology and allied subjects and little on natural history. The fund of $10,000 annually, granted by the legislature of 1907 and extended for two years more by that of 1909, has been practically all expended on highways. A small amount of most needful work was done on Southwestern Wisconsin but no general survey of the lead and zinc district has been undertaken. Practically nothing has been done on the water power survey which was also authorized by the legislatures of 1907 and 1909, as the whole of the money granted by the laws, has been imperatively demanded for highways. As this report shows, several comparatively small pieces of work have been accomplished but the larger projects have had to be postponed. With

the passage of a state highway law the funds of Survey will be relieved of the care of this part of the work; and if the legislature will continue the appropriations already made to the Survey these larger and very important matters can be taken up and completed.

I repeat, therefore, from the Sixth Biennial Report certain paragraphs which refer to these investigations:

"1. *Water Powers.* The water powers of the state require much more study. Many of the larger rivers are still unsurveyed. Of these may be mentioned the St. Croix, the Upper Chippewa, the Upper Wisconsin, the Wolf, Oconto, Menomonee, White, Bad, Trempealeau, and the La Crosse Rivers. Those rivers which have been surveyed need much more study. Just at the present time there is a pressing demand from the national government and from legislative committees for information regarding the water powers. No such data are at hand as are necessary for the information asked. Knowledge of the water powers is required in a completeness and detail which can be supplied only by years of work devoted to stream surveys and gaugings. There can be no doubt that the knowledge thus sought is not only valuable but necessary. Many of the facts now asked for could be given had the Legislature thought it wise to give money enough to permit the rapid carrying on of this branch of the Survey.

"2. *Southwestern Wisconsin.* The lead and zinc district needs much more study. The Survey has made topographical and geological maps of the more important regions where mining is now carried on. These scattered areas should be connected, and a map of the entire district should be published. Several years of field work will be necessary to complete this. This work should be done in advance of exploration, to serve as a guide for the drill men in their search for ore. It should not be necessary for them to spend thousands of dollars in looking for ore in places where there was practically no chance of finding it. The Survey has been able to do very little thus far in the study of the ores and of their origin, and of the manner of their deposition. It cannot be doubted that such study would lead to scientific results of much value, and also yield, as such work is sure to do, knowledge of great practical importance to prospectors, being helpful to them in developing new districts.

3. *Topography.* "In my last biennial report I referred to the necessity of beginning work on the preparation of a topographical map of the state and shall make only brief reference to the matter at this place. The preparation of such a map is one of the duties committed to the Survey by the original law which created it; yet nothing has been done by the State in this direction, since pressing necessities of other branches of investigation gave them precedence. The United States Geological Survey has issued topographical maps covering the southern portion of the state, about as far north as Milwaukee, but this survey is no longer being extended, nor is there reason to believe that much will be done until the State is ready to cooperate with the National Government in the work."

The need for topographic maps of the state such as are prepared by the United States Geological Survey is becoming more and more urgent. These maps are needed as a basis for a great deal of work which the state must do in the near future. A topographic map is almost a necessity as a basis for soil maps and geological maps. They are much needed in connection with the state forest reserves, and they give a great deal of information that will be valuable to the state in its road building.

These maps are also valuable in that they show the existence of water powers and the area of drainage basins tributary to these powers. The State Water Commission of New York uses them as a basis from which to compute the capacity of storage reservoir sites. They also furnish a basis for swamp land drainage, which is becoming of great importance in this state. These maps are also of much use for educational and other purposes. The United States Geological Survey has made a practice for some years of cooperating with states that appropriate money for the making of such topographic maps. They have a trained force of topographers and do an exceedingly high grade of work. It is highly desirable that a special continuing appropriation be made for the purpose of extending this topographic mapping as rapidly as possible.

4. *Educational Bulletins.* The preparation of educational bulletins is a branch of the work which the Survey was directed to undertake, but to which it has been able to devote but little money. Two or, perhaps three, such bulletins have been issued, all of which have been very successful. Those on Devil's Lake

and on the lakes of the southeastern part of the State are now out of print, but the Survey has now in hand the manuscript for a second edition of the last named. Work has been started on a bulletin giving an account of the general geology of the State. This should be pushed to completion, and in addition the Survey ought to be able to extend its work so as to make a complete report upon the physical geography of Wisconsin. Few states of the Union, perhaps, offer larger opportunities for an instructive report on this subject, and the interests of education as well as of science would be greatly advanced by its preparation.

Two bulletins of this nature, one on the geology of the state and one on its geography and manufactures are in preparation and will probably be ready for the press during the coming year.

5. Besides these subjects of special importance, there are the subjects on which study has been going on for some years. These are the geology of the Northwestern Area by Dr. Weidman; the study of the lakes by the Director and Mr. Juday; and the report on fish by Mr. Wagner. These will require in the next two years about the same sums as in the past, but it should also be possible to appoint an assistant who could give his whole time to the preparation of a report on the fish of the state, especially those of the inland waters, dealing with their nature, their distribution, their habits, and their food. This would require several years, but it is important, and fully justifies the time expended upon it.

6. *Highways.* The most important recommendations which I have to offer concern the policy of the State with regard to giving state aid for road building. That there is an overwhelming public sentiment in favor of adopting such a policy, was shown by the large majority given to the amendment to the constitution to make this possible, and the same sentiment was found by the special committee of the legislature of 1909 in their hearings throughout the state.

The most important thing in adopting such a policy is to provide for the efficient spending of the state funds. As stated in the report of the work of the highway division, there is enough money already being spent every year in the state to build good roads if it were spent efficiently. The most important function of state aid in this matter accordingly, will be to insure that the local money spent in conjunction with state aid shall be

used in the most efficient manner possible. This can only be accomplished by putting the administration of these funds under the supervision of the best trained road builders that can be secured.

A careful study of the laws of other states has been made and the results obtained under these laws have been learned in many cases by personal consultation with the state officials in charge. From this study it appears that the best results are to be secured by putting the work in charge of a board or commission, serving without pay and working through a chief engineer and assistants whom they appoint. Such commissions are in charge of the work in many states and are giving the best of satisfaction. They meet several times a year and give personal directions for the work of their employes in the same manner as a number of boards which we have at present in this state, viz. the Board of Commissioners of this Survey, the Fish Commission, the Capitol Commission, and the Boards of Regents of the Normal Schools and of the University.

In beginning this policy of state aid for roads, it appears that the work could be started most efficiently under the direction of the Geological and Natural History Survey. This organization is more thoroughly in touch with the situation and needs of the state through the four years' work of the highway division than any new commission could be. The work could be started with least expense and difficulty by simply enlarging the duties and authority of this division. The necessary force of experienced engineers will be difficult to obtain. If the highway division were put in charge, new inexperienced men could be worked in under the direction of the thoroughly experienced men already employed. A newly made commission would not be familiar with conditions and would not be able to start the work as quickly and efficiently.

Whether the work be done under the direction of this Survey or whether a new commission be formed, there are certain things which should be embodied in the law establishing a state highway department. It should be recognized that this work is technical in its nature and the active work should be in charge of properly trained and experienced men. In order to obtain and hold such men it is necessary that their tenure of office should be for the period of efficient service and should not

be subject in any way to considerations of politics. The state highway department should be given ample authority to insure the efficient spending of state money. It will not be necessary to have a great force of engineers employed by the state if the plans are carefully made. Such of the work as can be done more cheaply by local people can be delegated to them, and in this way a moderate sized force in the employ of the state will be able to give the work proper supervision.

Other matters, such as the details of the distribution of funds, and constructing and maintaining the roads, etc., have been carefully considered and the Survey will be ready to counsel at the proper time with the committees of the legislature having the matter under consideration, if such counsel is desired. The most important considerations which I wish to emphasize at this time are the importance of getting a non-political unsalaried commission with experienced engineers in their employ, and giving them all needed authority to insure the efficient spending of state funds.

7. *The Soil Survey.* Little need be said as to the future needs of this division. The legislature will no doubt continue the appropriation made two years ago, and with the aid of the U. S. Bureau of Soils, the survey can be prosecuted at a sufficiently rapid rate. It is already evident that the ten years, stated to the legislature as the time necessary for the completion of the first survey of the soils, will be needed. The older parts of the state demand a more detailed treatment than was at first thought necessary. The assistance and cooperation of the Department of Agriculture, however, enables the Survey to cover with its field parties as large an area as was planned at first.

FINANCIAL REPORT.

EXTRACTED FROM THE REPORT OF THE SECRETARY OF STATE.

DISBURSEMENTS, JULY 1, 1908–JUNE 30, 1909.

Birge, F. A., director, salary and expenses	$617 56	
Bostow, W. C., draughtsman	411 69	
Bailey, F. M., services	114 08	
Bates, F. E., services	28 10	
Cox, G. H., geologist	500 00	
Colladay, E. B., services	50 30	
Canfield, F. H., services	51 45	
Christopher, R. T., services	53 33	
Diemer, M. E., services	57 36	
Deming, R. E., services	7 80	
Fisher, S. M., services	17 70	
Glaettli, John, services	28 25	
Gilman, E. D., services	22 95	
Gleason, M. G., services	5 50	
Hotchkiss, W. O., geologist, salary and expenses	2,002 49	
Hall, F. S., assistant, salary and expenses	805 54	
Hirst, A. S., engineer, salary and expenses	2,785 78	
Halbert, C. A., services	15 81	
Hinds, J. W., assistant, salary and expenses	367 97	
Hall, S. D., services	97 17	
Jackson, H. H. T., services	273 44	
Judav Chaney, biologist, salary and expenses	1,160 18	
Keeling, B. F., assistant, salary and expenses	1,246 13	
Kirchhens, Adelaide, services	10 25	
Kemmerer, George, services	60 00	
Leiter, Victor, services	10 00	
Le Grand, A. J., services	98 32	
Loring, W. H. J., services	12 00	
Martin, Laurence, services	727 00	
Mixer, A. G., services	49 46	
Moore, S. L., services	15 00	
Mott, W. S., services	18 00	
Marshall, Sloth, services	75 00	
Richardson, W. D., services	28 00	
Ogden, H. J., services	29 00	
Smith, J. M., services	80 00	
Sampson, F. B., clerk	275 00	
Torkelson, M. W., engineer, salary and expenses	2,124 38	
Thwaites, F. T., assistant, salary and expenses	710 75	
Tomlinson, W. H., services	32 97	
Vorhies, C. T., services	100 90	
Weidman, S., geologist, salary and expenses	2,202 32	
Wagner, George, services	36 28	
Wells, W. C., stenographer	630 00	
American Express Co., expressage	285 00	
Bausch & Lomb Optical Co., supplies	7 30	

Cantwell Printing Co., supplies	25 00	
Carpenter, G. B., & Co., supplies	54 60	
Dietzgen, Eugene, Co., supplies	79 06	
Democrat Printing Co., printing	2,694 09	
Eastman, J. S., supplies	2 15	
Fass, Joseph & Co., supplies	30 50	
Findorff, J. H., supplies	9 00	
Gebhardt, Carl, supplies	3 00	
Hoen, A., & Co., maps	1,767 00	
Haswell Furniture Co., supplies	84 75	
Hollister Drug Co., supplies	12 30	
Haak, William, Jr., supplies	28 84	
Keuffel & Esser Co., supplies	4 48	
Kemmerer, George, photographs	64 00	
Lutman, B. F., supplies	9 80	
Madison Tent & Awning Co., supplies	6 50	
Madison Engraving Co., cuts	1 03	
North Western Lithographing Co., maps	261 17	
National Distilling Co., supplies	29 17	
Oshkosh Gas Light Co., supplies	20 00	
Parsons Printing & Stationery Co., supplies	87 60	
Polk, R. L., & Co., book	6 00	
Smithsonian Institution, exchanges	68 70	
Sargent, E. H., & Co., supplies	42 77	
Streissguth-Petran Engraving Co., cuts, etc	30 05	
United States Express Co., expressage	169 18	
University Co-operative Co., supplies	19 68	
Whitall-Tatum Co., supplies	53 20	
Wolf, Kubly & Hirsig, supplies	12 70	
Wisconsin Central Ry. Co., freight	16 24	
Wells, Fargo & Co., expressage	2 71	
		$24,997 37

DISBURSEMENTS, JULY 1, 1909–JUNE 30, 1910.

Allen, Thomas, compassman	$112 00	
Birge, E. A., director, salary and expenses	791 59	
Balsey, F. M., services	83 18	
Brightman, Herbert, teamster	48 67	
Besaw, George, cook	32 50	
Brewer, B. C., stenographer	82 60	
Baker, O. E., assistant	118 43	
Barnes, R. A., services	75 00	
Colladay, E. B., services	150 95	
Christopher, R. T., services	246 66	
Cenfield, F. H., services	17 10	
Charron, Paul, cook	49 73	
Conrey, Guy, chemist	617 70	
Crampton, B. L., services	8 10	
Dunnewald, T. J., assistant	501 96	
Dudgeon, S. B., assistant	137 00	
Davis, J. B., services	10 00	
Evans, W. J., services	19 29	
Gray, James, compassman	27 00	
Glaettli, A., Jr., services	4 20	
Graul, E. J., analyst	50 00	
Hotchkiss, W. O., geologist, salary and expenses	3,955 53	
Hirst, A. R., engineer, salary and expenses	2,932 03	
Hall, E. B., geologist, salary and expenses	259 99	
Huels, F. W., special assistant, salary and expenses	810 52	
Hall, S. P., services	99 30	
Havard, F. T., services	7 00	
Juday, Chancey, geologist, salary and expenses	1,719 41	
Jones, E. R., expert	148 63	
Johns, Louise, analyst	529 18	
Kuelling, H. J., assistant engineer, salary and expenses	1,789 17	
Kuhlman, A. H., assistant	301 50	
Kemmerer, George, services	38 10	
Le Grand, A. J., services	175 05	
Lorenz, E. H. J., work on model	787 43	
Lynes, George, compassman	83 61	
Lorenz Model Co., services	63 35	
Leutzinger W. A., services	15 25	
Langwell, J. S., services	1 20	
Musback, F. L., assayist, salary and expenses	1,503 53	
Mitchell, W. R., services	29 16	
Meyer, A. H., assistant	444 45	
Nebel, Walter, assistant	5 75	
Nelson, Oran, services	1 00	
Nourse, S. D., labor	17 00	
Pickering, H. G., services	20 85	
Peltier, G. L., labor	62 80	
Quan, C. E., stenographer	12 95	
Rigden, E. J., services	41 00	
Sanford, F. G., clerk	325 00	
Stoddart, C. W., chemist	743 95	
Schoenmann, L. R., assistant, salary and expenses	497 10	
Spraker, E. B., assistant, salary and expenses	624 00	
Smith, A. J., services	8 00	
Torkelson, M. W., engineer, salary and expenses	2,620 02	
Thwaites, F. T., assistant geologist, salary and expenses	770 00	
Truog, Emil, assistant	175 00	
Toole, E. H., services	58 30	
Wells, W. C., stenographer	664 53	
Wells, W. C., Estate of, salary	34 00	
Weidman, S., geologist, salary and expenses	3,035 31	
Walster, H. L., assistant	126 02	
Ward, O. G., draftsman	50 05	
Whitson, A. R., services	185 76	
American Express Co., expressage	171 32	
Ashley, H. E., expenses	39 00	

Bishop, J., & Co., supplies	321 40	
Baker, J. T., Chemical Co., supplies	71 38	
Bleininger, A. V., expenses	38 40	
Cantwell Printing Co., supplies	59 25	
Carpenter, G. B., Co., supplies	44 00	
Curtiss, F. W., prints	46 25	
Democrat Printing Co., printing	151 15	
Dietzgen, Eugene, Co., supplies	108 26	
Dyke, L. G., expenses	10 99	
Estes, R. L., Agent, typewriter rent	1 50	
Fass, Joseph, & Co., supplies	5 25	
Gould, Wells & Blackburn Co., supplies	15 00	
Grimm's Book Bindery, supplies	46 16	
Gallagher, John, Co., supplies	15 00	
Gurley, W. & L. E., supplies	106 16	
Haswell Furniture Co., supplies	117 85	
Hoen, A. & Co., cuts	165 00	
Haak, William, Jr., supplies	16 00	
Illinois Electric Co., supplies	14 00	
Indiana Road Machine Co., machine	81 50	
Illinois Central R. R. Co., freight	4 65	
Kny, Scherer Co., instruments	54 00	
Kenoyn Printing & Mfg. Co., books	15 00	
Laun, Mangold & Co., supplies	30 58	
Mandel Engraving Co., cuts	3 30	
Madison Tent & Awning Co., supplies	6 75	
Mead, W. J., books	10 00	
Mautz Bros., supplies	10 27	
National Distilling Co., supplies	27 18	
Niedecken, H., Co., supplies	40 00	
Oscar, N. M., books	5 00	
Polk, R. L., & Co., directory	6 00	
Parsons Printing & Stationery Co., supplies	51 13	
Plantz, Samuel, expenses	5 74	
Post, L. M., repairs	9 80	
Streissguth-Petran Engraving Co., cuts	49 71	
Sargent, E. H., & Co., supplies	276 57	
Smith's Livery, livery	12 25	
Smithsonian Institution, exchanges	31 45	
Torison Balance Co., supplies	35 00	
Veeder & Veeder, books	5 00	
University Co-operative Co., supplies	2 30	
Wells, Fargo & Co., expressage	74 19	
Whitall Tatum Co., supplies	45 72	
Wagner, George, expenses	32 80	
Wright Bros. Co., supplies	17 20	
Kenyon Printing & Mfg. Co., books	15 00	
West, H. H., Co., supplies	10 00	
		$31,563 28

STATUTES OF WISCONSIN RELATING TO THE GEOLOGICAL AND NATURAL HISTORY SURVEY.

CHAPTER 297, LAWS OF 1897.

An Act to provide for the investigation of the natural resources of the state of Wisconsin, and providing an appropriation therefor.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. There is hereby constituted a geological and natural history survey of the state of Wisconsin.

SECTION 2. This survey shall have for its object:

(1) The completion of the geological survey of the state, and especially the examination of the rocks, with reference to the occurrence of iron ores, building stones, and other valuable mineral products, and in reference to their value as material for road construction.

(2) A study of the soils of the state.

(3) A study of the plants of the state, and especially of the forests, with reference to their cultivation and preservation.

(4) A study of the animal life of the state, and especially the occurrence, distribution and production of fish in the lakes and streams of the state, and a study of foods and enemies of fish.

(5) The preparation of an account of the physical geography and natural history of the state, in such form as to serve as manuals for the public schools, and of special reports on subjects of economic importance, in such form as to be of direct service to the people.

(6) The completion of the topographic map of the state begun by the United States Geological Survey; but no money shall be expended for topography unless an equivalent amount be expended for this purpose in the state by the United States government.

SECTION 3. This survey shall be governed by a board of commissioners, consisting of the governor of the state, the state superintendent of public instruction, the president of the state university, the president of the commissioners of fisheries, and the president of the Wisconsin academy of sciences, arts, and letters. The commissioners shall meet within thirty days after the passage of this act, and organize as a commission and adopt by-laws fo rtheir government, not inconsistent with law, and shall meet at such time and places as they may prescribe. A majority shall be a quorum. They shall receive no compensation, but each shall be reimbursed his expenses actually and necessarily incurred in the performance of his official duties, out of such appropriation as may be made by the legislature. They shall choose from their number a president, secretary, and such

other officers as their by-laws may prescribe; but no officer shall receive any compensation, except such as is herein provided for. The commissioners shall have general charge of the survey, and shall appoint a superintendent of the survey, and, on his nomination, such assistants and employes as they may deem necessary. They shall fix the compensation of all persons employed in the survey, and may remove them at pleasure.

SECTION 4. It shall be the duty of the commissioners to prepare a report before the meeting of each legislature, showing the progress and condition of the survey, giving an account of money spent together with such other information as may be deemed necessary and useful. The superintendent shall transmit to the commissioners, from time to time, special reports, with necessary illustrations and maps, as these are completed. If approved by the commissioners, they shall be transmitted to the commissioners of public printing, who are authorized to have the reports published in a suitable manner, as independent reports, as bulletins of the state university, or in the transactions of the Wisconsin academy of sciences, arts, and letters, as the commissioners of the survey deem best. If published as independent reports, it shall be the duty of the commissioners of public printing to decide as to the number of copies in the edition of each particular report. Five copies of each report shall be delivered to each of the state officers, and to each member of the legislature. The number of copies provided by law for other public documents shall be furnished to the state historical society, the library of the state university, and other state institutions. The remainder of the independent reports shall be distributed, used in exchange, or sold by the commissioners of the survey, as the interest of the state and of science demands. All moneys obtained by the sale of the report shall revert to the state treasury, as a part of the general fund. Volumes obtained in exchange for the reports shall be added to the library of the Wisconsin academy of sciences, arts, and letters. The superintendent of public property shall furnish, upon the requisition of the president of the commissioners of the survey, such stationery and postage stamps as may be necessary for the use of the commissioners and the superintendent of the survey in official business.

SECTION 5. After material collected shall have served for the purposes of the survey, it shall be distributed to the state university, the colleges of state, the state normal schools, and the free high schools of the state, under the approval of the commissioners of the survey, in such a manner as to be of the greatest advantage to education in the state.

SECTION 6. There is hereby annually appropriated for two years to the commissioners of the geological and natural history survey, out of any money in the treasury not otherwise appropriated, the sum of $5,000, the first appropriation to be paid in the current fiscal year.

SECTION 7. This act shall take effect and be in force from and after its passage and publication.

Approved April 22, 1897.

CHAPTER 163, LAWS OF 1899.

An Act to appropriate a sum of money for the further prosecution of the geological and natural history survey of the state.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. There is hereby appropriated for the further prosecution of the geological and natural history survey, out of any money in the

treasury not otherwise appropriated, the sum of ten thousand dollars annually for the term of two years. This money shall be expended by the commissioners of said survey for the purpose of executing the duties assigned to them by chapter 297 of the laws of 1897.

SECTION 2. This act shall take effect and be in force from and after its passage and publication.

Approved April 12, 1899.

CHAPTER 375, LAWS OF 1901.

An Act to appropriate a sum of money for the further prosecution of the geological and natural history survey of the state.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. There is hereby appropriated for the further prosecution of the geological and natural history survey, out of any money in the treasury not otherwise appropriated, the sum of five thousand dollars annually. This money shall be expended by the commissioners of said survey for the purpose of executing the duties assigned to them by chapter 297 of the laws of 1897, and any other duties which may be assigned to them by the legislature.

SECTION 2. This act shall take effect and be in force from and after its passage and publication.

Approved May 13, 1901.

CHAPTER 176, LAWS OF 1903.

An Act to appropriate money for the further prosecution of the geological and natural history survey of the state.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

Appropriation of $5,000 additional. SECTION 1. There is hereby appropriated for the further prosecution of the geological and natural history survey of the state, out of any moneys in the treasury not otherwise appropriated, the sum of five thousand dollars annually, in addition to the sum now appropriated by law. This money shall be expended by the commissioners of said survey for the purpose of executing the duties assigned to them by chapter 297 of the laws of 1897, and any other duties which may be assigned to them by the legislature, and especially for the investigation of the clays and clay industries and the completion of the survey of the lead region.

SECTION 2. This act shall take effect and be in force from and after its passage and publication.

Approved May 6, 1903.

CHAPTER 475, LAWS OF 1905.

An Act to provide for ascertaining the amount of available water power in this state and making an appropriation therefor.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. The geological and natural history survey of the state of Wisconsin is directed to cause survey to be made of the water powers of the state for the purpose of ascertaining the amount of available water power in this state, developed and undeveloped, and the location of the same. Such work may be done in conjunction with the United States geological survey. Upon the completion of such

survey a full report thereof shall be made to the governor for the use of the legislature. The sum of two thousand five hundred dollars or so much thereof as may be necessary is hereby appropriated out of any money in the treasury not otherwise appropriated, to defray the expense of such survey.

SECTION 2. This act shall take effect and be in force from and after its passage and publication.

Approved June 20, 1905.

CHAPTER 458, LAWS OF 1909.

An Act to amend section 392 l of the statutes, relating to the geological and natural history survey, and making an appropriation therefor.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. Section 392 l of the statutes is amended to read: Section 293 l. 1. The geological and natural history survey is directed to investigate and to carry on such experimental work in road building, different methods of construction, kinds of material, and systems of drainage as will enable it to determine upon the various methods of road construction best adapted to the various sections and soils of the state, the cost of the same and recommend standards for the construction of highways in the various sections of the state. It may be consulted by county, city, village or township officers having charge over highways and bridges, and shall when requested advise and give without charge information to such officers relative to the construction, repairing, alteration and maintenance of said highways and bridges.

2. Local road authorities are required to furnish the Geological and Natural History Survey data as to the mileage, cost, maintenance, condition and character of roads under their supervision, upon the written request of and on blank forms supplied by said Geological and Natural History Survey.

3. Said Geological and Natural History Survey is further directed to extend the survey of the lead and zinc region beginning with districts which are at present of greatest economic importance.

4. Said Geological and Natural History Survey is further directed to continue the survey of the water powers of the state. This last survey may be made in conjunction with tne United States Geological Survey.

5. Upon completion of the work named, full reports shall be made to the governor for the use of the legislature. The sum of ten thousand dollars annually for two years is hereby appropriated to defray the expense of executing these duties or other duties assigned to the said survey by the legislature.

This chapter is a reenactment, without substantial change, of chap. 641, laws of 1907.

CHAPTER 403, LAWS OF 1909.

An Act to create section 392k—1 of the statutes, relating to a soil survey, and making appropriation therefor.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. There is added to the statutes a new section to read: Section 392k—1. The geological and natural history survey of the

state of Wisconsin is directed to cause a soil survey and a soil map of the state to be made for the purpose of ascertaining the character and fertility of the developed and undeveloped soils of the state, the extent and practicability of drainage of swamp and wet lands of the state, and the means for properly conserving and increasing the fertility of the soil of the state, such work to be carried on in cooperation with the college of agriculture of the University of Wisconsin. The sum of ten thousand dollars annually for the biennial period ending June 30, 1911, is appropriated out of any money in the treasury not otherwise appropriated for the purpose of such survey.

SECTION 2. This act shall take effect and be in force from and after its passage and publication.

Approved June 15, 1909.

PUBLICATIONS

OF THE

Wisconsin Geological and Natural History Survey.

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1. BULLETINS.

The publications of the Survey are issued as (1) bulletins, which are numbered consecutively, (2) road pamphlets, (3) biennial reports, and (4) hydrographic maps. These publications are independently paged and indexed, no attempt being made to group them in volumes.

1. BULLETINS.

The bulletins are issued in three series:

Scientific Series.—The bulletins so designated consist of original contributions to the geology and natural history of the state, which are of scientific interest rather than of economic importance.

Economic Series.—This series includes those bulletins whose interest is chiefly practical and economic.

Educational Series.—The bulletins of this series are primarily designed for use by teachers and in the schools.

The following bulletins have been issued.

Bulletin No. 1. Economic Series No. 1.

On the Forestry Conditions of Northern Wisconsin. Filibert Roth, Special Agent, United States Department of Agriculture. 1898. Pp. vi, 78; 1 map. *Out of print.*

Bulletin No. II. Scientific Series No. 1.

On the Instincts and Habits of the Solitary Wasps. George W. Peckham and Elizabeth G. Peckham. 1898. Pp. iv, 241; 14 plates, of which 2 are colored; 2 figures in the text. Sold at the price of $1.50 in paper and $2.00 bound.

Bulletin No. III. Scientific Series No. 2.

A Contribution to the Geology of the Pre-Cambrian Igneous Rocks of the Fox River Valley, Wisconsin. Samuel Weidman, Ph. D., Assistant Geologist, Wisconsin Geological and Natural History Survey. 1898. Pp. iv, 63; 10 plates; 13 figures in the text. *Out of print.*

Bulletin No. IV. Economic Series No. 2.

On the Building and Ornamental Stones of Wisconsin. Ernest Robertson Buckley, Ph. D., Assistant Geologist, Wisconsin Geological and Natural History Survey. 1898. Pp. xxvi, 544; 69 plates, of which 7 are colored, and 1 map; 4 figures in the text. Sent on receipt of 30c.

Bulletin No. V. Educational Series No. 1.

The Geography of the Region About Devil's Lake and the Dalles of the Wisconsin, with some notes on its surface geology. Rollin D. Salisbury, A. M., Professor of Geographic Geology, University of Chicago, and Wallace W. Atwood, B. S., Assistant in Geology, University of Chicago. 1900. Pp. x, 151; 38 plates; 47 figures in the text. *Out of print.*

Bulletin No. VI. Economic Series No. 3. Second Edition.

Preliminary Report on the Copper-Bearing Rocks of Douglas county, and parts of Washburn and Bayfield Counties, Wisconsin. Ulysses Sherman Grant, Ph. D., Professor of Geology, Northwestern University. 1901. Pp. vi, 83; 13 plates. Sent on receipt of 10c.

Bulletin No. VII. Economic Series No. 4.

The Clays and Clay Industries of Wisconsin. Part I. Ernest Robertson Buckley, Ph. D., Geologist, Wisconsin Geological and Natural History Survey. 1901. Pp. xii, 304; 55 plates. Sent on receipt of 20c.

Bulletin No. VIII. Educational Series No. 2.

The Lakes of Southeastern Wisconsin. N. M. Fenneman, Ph. D., Professor of General and Geographic Geology, University of Wisconsin. 1902. Pp. xv, 178; 36 plates, 38 figures in the text. A second edition has been issued and will be sold at the price of 50c.

Bulletin No. IX. Economic Series No. 5.

Preliminary Report on the Lead and Zinc Deposits of Southwestern Wisconsin. Ulysses Sherman Grant, Ph. D., Professor of Geology, Northwestern University. 1903. Pp. viii, 103; 2 maps, 2 plates, 8 figures in the text. *Out of print.*

Bulletin No. X. Economic Series No. 6.

Highway Construction in Wisconsin. Ernest Robertson Buckley, Ph. D., State Geologist of Missouri, formerly Geologist, Wisconsin Geological and Natural History Survey. 1903. Pp. xvi, 339; 106 plates, including 26 maps of cities. Sent on receipt of 30 cents.

Bulletin No. XI. Economic Series No. 7. Second Edition.

Preliminary Report on the Soils and Agricultural Conditions of North Central Wisconsin. Samuel Weidman, Ph. D., Geologist, Wisconsin Geological and Natural History Survey. 1903. Pp. viii, 67; 10 plates, including soil map. Second edition, 1908. Sent, paper bound, on receipt of 10 cents; cloth bound, 20 cents.

Bulletin No. XII. Scientific Series No. 3.

The Plankton of Lake Winnebago and Green Lake. C. Dwight Marsh, Ph. D., Professor of Biology, Ripon College. 1903. Pp. vi, 94; 22 plates. Sent, paper bound, on receipt of 10 cents.

Bulletin No. XIII. Economic Series No. 8.

The Baraboo Iron-bearing District of Wisconsin. Samuel Weidman, Ph. D., Geologist, Wisconsin Geological and Natural History Survey. 1904. Pp. x, 190; 23 plates, including geological map. Sent, paper bound, on receipt of 10 cents.

Bulletin No. XIV. Economic Series No. 9.

Report on Lead and Zinc Deposits of Wisconsin. Ulysses Sherman Grant, Ph. D., Professor of Geology, Northwestern University. 1906. Pp. ix, 100; 8 plates; 10 figures in the text; an atlas containing 18 maps; and a supplementary atlas containing 6 maps; issued in 1909. Sent on receipt of 25 cents.

Bulletin No. XV. Economic Series No. 10.

The Clays of Wisconsin and Their Uses. Heinrich Ries, Ph. D., Assistant Professor of Economic Geology, Cornell University. 1906. Pp. xii, 259; 30 plates, including 2 maps; 7 figures in text. Sent on receipt of 18 cents.

Bulletin No. XVI. Scientific Series No. 4.

The Geology of North Central Wisconsin. Samuel Weidman, Ph. D., Geologist, Wisconsin Geological and Natural History Survey. Pp. xxxi, 697; 86 plates, including 2 maps; 38 figures in the text. 1907. Sent on receipt of 40 cents.

Bulletin No. XVII. Scientific Series No. 5.

The Abandoned Shore-lines of Eastern Wisconsin. J. W. Goldthwait, Ph. D., Assistant Professor of Geology, Northwestern University. Pp. x, 134; 38 plates; 37 figures in the text. 1907. Sent on receipt of 15 cents.

Bulletin No. XVIII. Economic Series No. 11.

Rural Highways of Wisconsin. W. O. Hotchkiss, B. S., Instructor in Geology, University of Wisconsin; in charge of Economic Geology, Wisconsin Geological and Natural History Survey. 1906. Pp. xiv, 135; 16 plates; 2 figures in the text. Sent on receipt of 10 cents.

Bulletin No. XIX. Economic Series No. 12.

Zinc and Lead Deposits of the Upper Mississippi Valley. H. Foster Bain. Director of State Geological Survey of Illinois. Washington, D. C. 1907. Pp. xii, 155; 9 plates, including 5 maps; 45 figures in the text. Sent on receipt of 6 cents.

This bulletin is a reprint of Bulletin No. 294 of the United States Geological Survey. *Only a small number of copies were reprinted for local use. It has not been sent out to libraries and exchanges.*

Bulletin No. XX. Economic Series No. 13.

The Water Powers of Wisconsin. L. S. Smith, C. E.; Engineer Wisconsin Geological and Natural History Survey; Engineer U. S. Geological Survey. Pp. xvi, 354; 54 plates; 17 figures in the text. 1908. Sent on receipt of 25 cents.

Bulletin No. XXI. Scientific Series No. 6.

The Fossils and Stratigraphy of the Middle Devonic of Wisconsin. Herdman F. Cleland. Professor of Geology, Williams College. Pp. 206; 55 plates. 1911. Sent on receipt of 25 cents.

Bulletin No. X II. Scientific Series No. 7.

The Inland Lakes of Wisconsin; the dissolved Gases of the Water and their biological Significance. Edward A. Birge and Chancey Juday. Pp. xxi, 254; 10 plates, 142 figures in text; all diagrams of gases and plankton. 1911. Sent on receipt of 15 cents.

ROAD PAMPHLETS.

Road Pamphlet No. 1.

Earth Roads. Arthur R. Hirst, B. S., Highway Engineer, Wisconsin Geological and Natural History Survey. Pp. 26; 13 figures. Sent on receipt of 2c postage.

Road Pamphlet No. 2.

The Earth Road Drag. Arthur R. Hirst, B. S. Highway Engineer, Wisconsin Geological and Natural History Survey. Pp. 16; 4 figures. Sent on receipt of 2c postage.

Road Pamphlet No. 3.

Stone and Gravel Roads. Arthur R. Hirst, B. S. Highway Engineer, Wisconsin Geological and Natural History Survey. Pp. 27; 11 figures. Sent on receipt of 2c postage.

Road Pamphlet No. 4.

Culverts and Bridges. Arthur R. Hirst, B. S. Highway Engineer, Wisconsin Geological and Natural History Survey. Pp. 47; 16 figures. Sent on receipts of 2c postage.

2. BIENNIAL REPORTS.

The Survey has published seven biennial reports, which relate to administrative affairs only and contain no scientific matter.

First Biennial Report of the Commissioners of the Geological and Natural History Survey. 1899. Pp. 31.

Second Biennial Report of the Commissioners of the Geological and Natural History Survey. 1901. Pp. 44.

Third Biennial Report of the Commissioners of the Geological and Natural History Survey. 1903. Pp. 35.

Fourth Biennial Report of the Commissioners of the Geological and Natural History Survey. 1904. Pp. 42.

Fifth Biennial Report of the Commissioners of the Geological and Natural History Survey. 1907. Pp. 45.

Sixth Biennial Report of the Commissioners of the Geological and Natural History Survey. 1909. Pp. 45.

Seventh Biennial Report of the Commissioners of the Geological and Natural History Survey. 1911. Pp. 55.

4. HYDROGRAPHIC MAPS.

There have been prepared hydrographic maps of the principal lakes of southern and eastern Wisconsin. This work is in charge of L. S. Smith, C. E., Associate Professor of Topographic and Geodetic Engineering, University of Wisconsin.

The maps are as follows:

		Size of Plate, Inches.	Scale. Inches per mile.	Contour. Interval, feet.
No. 1.	Lake Geneva	17.5x10.8	2	10
No. 2.	Elkhart Lake	15.5x13.1	5	10
No. 3.	Lake Beulah	22.5x20.0	6	10
No. 4.	Oconomowoc-Waukesha Lakes	29.8x19.1	2	10
No. 5.	The Chain of Lakes. Waupaca	21.7x20.6	6	10
No. 6.	Delavan and Lauderdale Lakes	22.5x16.8	4	10
No. 7.	Green Lake	26.0x17.8	3.2	20
No. 8.	Lake Mendata	23.7x19.5	6	5
No. 9.	Big Cedar Lake	18.0x13.5	2.9	10
No. 10.	Lake Monona	17.6x17.3	4	5

In all of these maps the depth of the lakes is indicated by contour lines, and by tints in all except No. 1. They are sent on receipt of 10 cents each and may be had either mounted in a manilla cover, or unmounted.

GEOLOGICAL MODEL OF WISCONSIN

The Survey has prepared a model which shows in great detail the topography of the state. It is designed for use in schools, libraries, and similar public institutions, and is 49 inches by 45 inches in size. It is supplied to such institutions in Wisconsin at the cost of labor and materials used in its construction. The form showing topography alone is furnished for $31 and the form showing geology in addition to topography is furnished for $46. A special circular with illustration of the model may be had on application.

All correspondence relating to the Survey should be addressed to

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